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OFFICE OF ROAD INQUIRY.

BULLETIN No. 3.

IMPROVEMENT

OF THE

ROAD SYSTEM OF GEORGIA.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Road Inquiry,
Washington, D. C., March 14, 1894.

Sir: I have the honor to submit the accompanying paper on road improvement, prepared by Mr. O. H. Sheffield, of the University of Georgia, and to recommend its publication as a bulletin of this Department. Mr. Sheffield received for this paper in the fall of 1892 the prize offered by the State Agricultural Society of Georgia for the best essay on the improvement of the road system of Georgia. Its merit as a contribution to the literature of the good-roads movement makes its distribution desirable, especially in the Southern States.

Very respectfully,

Roy Stone,
Special Agent and Engineer in Charge.

Hon. J. Sterling Morton,
Secretary.

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IMPROVEMENT OF THE ROAD SYSTEM OF GEORGIA.

INTRODUCTORY.

The proposition that the roads of a country are infallible signs of its civilization needs no proof. They are recognized by all educated men as an unmistakable physical indication of the attainments of any people in science, industry, and wealth. Simultaneous with the emergence of man from the barbarous state came the demand for better facilities of communication, and it has grown proportionately with his development. Roads are at once a factor in the development of civilized society and an evidence of its attainments.

Judged by this criterion we, as a nation, unfortunately fall far short of the standard of excellence as exemplified by the splendid road systems of England, France, Italy, Germany, and even far-off British India. Yet, in accepting this criterion, we can not fail to credit to Americans the grandest railway system in the world, in the extraordinary growth and development of which, however, the common roads have been the sufferers.

DEMANDS OF COMMERCE.

The tendency of the times is along the lines of selfish interest, to the aggrandizement of self—to the accumulation of wealth regardless of considerations of economic conditions looking to the permanency of the Government and the stability of its institutions. As a result the cities are becoming overpopulous, because of their greater advantages for the accumulation of money, while the country districts are becoming rapidly depopulated—a condition of things which, if persisted in, must lead to inevitable disaster. For this state of affairs the roads of the country are undoubtedly in a great measure responsible. The country districts require facilities of communication among themselves and with the markets and marts of trade, which will put them, as nearly as may be, on an equal footing with their more fortunate neighbors, the railroad towns. Otherwise the rural population will be unable to compete with the cities, and, as a result, will leave the farms for the cities and towns. The latter, however, require—indeed, must have—the support of the

stable population of the rural districts, and hence the seriousness of the question which confronts us of the necessity of improving the common roads of the State as an inducement for the agricultural classes to remain upon the farm.

NECESSITY FOR BETTER HIGHWAYS.

Of the necessity for better highways no argument should be necessary to convince us, since we have only to look to Europe for an example of the actual results of the improvements of the public roads. The magnificent systems of common roads maintained in those countries for almost a century past have demonstrated the wisdom of their promoters, and actual statistics show the economy which they have worked to the people by whom they are supported. True, the conditions here are not identical with those of European countries, but it is only in the matter of population that they materially differ. To demonstrate, however, the feasibility of some such system in this State shall be the aim and object of this paper, and its purpose to show by actual figures the economy from a financial standpoint, which is recognized as the most potent argument that can be brought to bear upon the people of this day and age. People can be induced to take little stock in enterprises which do not promise a substantial return to them in money, or its equivalent in some definite and unmistakable form. And rightly so, too; for the depressed financial condition of the people of the country properly permits only such legislation as can be shown to afford direct public benefit. In view of this fact it would seem most unwise and inexpedient to levy any additional tax upon a people already greatly burdened, unless it can be clearly shown that by a small increase of the tax rate an actual saving to the taxpayer results, leaving him at the end of the year the gainer by the institution of the change. This we propose to show in regard to the construction and maintenance of the common roads of the State.

In this discussion there is one fundamental proposition which it is only necessary to state, as of its truth and correctness there is almost a unanimous opinion upon the part of the thinking men of Georgia, viz, that the present road system is wholly unsatisfactory, and that some change is demanded in keeping with the civilization and adequate to the demands of the people of this great Commonwealth.

This proposition being laid down, then the question presents itself, How are we to make this much-needed improvement? On this point we need hesitate but little, as it could scarcely be worse, no matter what system should be adopted. However, it is proposed in the subsequent pages of this article to discuss the questions involved in the making and maintaining of the common roads and by what system the interests of the whole people will be best subserved.

The subject of roads may be discussed under the three heads of location, construction, and maintenance.

ROAD LOCATION.

Under the first head it may be said that, other things being equal, the road between two given points should be laid out in the most direct line. This, however, is so indefinite in its meaning that it may as well be said that other things seldom are "equal"; so that the problem of the best location requires very important and careful consideration upon the part of an expert engineer or road-builder. The savage, without compass to guide and proceeding along the line that least impeded his progress, left a network of winding trails which the civilized white man followed and opened up as roads. The custom seems to have been handed down from "sire to son," so that even now in many localities the roads wind and turn in almost all conceivable directions, and often without any show of reason for it. On the other extreme, there are roads that stretch away for miles over hills and valleys in a perfectly straight line, without any particle of regard for the heavy grades encountered thereby. The latter were constructed upon the idea, no doubt, that the straight line is the shortest distance between two points—a proposition which is mathematically true; but in the problem of road-making the engineer frequently finds that an actual saving of distance results from going around steep hills instead of over them in the direct line. In point of the work performed in drawing a load over a hill as against going around on an easier grade, the advantage is very often in favor of the latter.

PRELIMINARY SURVEYS.

These are problems for the solution of the engineer, and no road should have any permanent improvement made upon it without the judgment of some such competent person being first passed upon it. In the determination of this question he would be influenced by considerations of the grades on the direct line, and the cost of reducing the same to a certain allowable grade, previously determined as the standard, as compared with the longer line and lighter grades. Some figures to illustrate this point will be given under the head of "grade" further on in this discussion. The road in all cases, except in the case of pleasure drives, where considerations of commerce enter not as a factor, should be laid out in an absolutely straight line, where the configuration of the country will admit of it and no uncommon obstacle interposes to prevent. Where curves are necessary they should be regular and of large radius, more particularly when the character of the traffic is such that long wagons and teams would have to pass along the route; and really there is scarcely any road where they might not be expected to pass at some time, and consequently should be provided for by making the minimum radius sufficient to meet the exigencies of probable cases.

ROAD CONSTRUCTION.

The preliminary surveys having been made and mapped, and the location determined from these data, it remains to stake out the road ready for the work of construction.

WIDTH.

Clearly this will depend upon the character of the highway and the amount of traffic. It is the consensus of opinion of experts that the width should be some multiple of 8 for the perfect security of teams passing each other rapidly. If it could be expected from the amount of traffic that as many as three teams would be likely to pass each other at the same time, then 24 feet would be a proper width to have the roadway. For ordinary country districts 16 feet would be ample, the 24-foot road being in the vicinity of towns and cities. The main thing to be considered in regard to width is the cost of construction and maintenance. It would be an unnecessary expenditure of money to maintain more than the width actually required for use. In speaking of the width above reference is had to the roadbed.

To secure the perfect access of wind and sunlight during a large part of the day, which are very essential to the drying of the roadway and its consequent preservation, all trees and shrubs for a distance of at least 12 feet each side of the roadbed should be cleared away, thus making the width of the two classes of roads referred to above 40 feet and 48 feet entire. The width of the road should not be considered an absolutely invariable quantity; as for example, it can easily be imagined how it might be found expedient sometimes to reduce the width where the obstacles encountered, such as a rock "cut" would cause heavy expense in construction. The due exercise of judgment and skill on the part of the engineer would determine such questions.

GRADES.

In this, as in the matter of width and degree of curve, no absolutely invariable rules can be adhered to, but, so far as it is deemed practicable to do so, some definite percentage should be determined upon as a maximum gradient to be allowed. The determination will depend upon the importance of the road. In most countries where elaborate systems have been instituted the roads are divided into three or four classes, depending upon their importance. In France, roads of the first class do not exceed a maximum grade of 3 per cent. On roads of the second class, the grade does not exceed 5 per cent, and on third-class roads a 7-per-cent grade may be allowed.

Numerous experiments have been made at different times to ascertain the effect of grade upon the tractive powers of animals. Obviously, none of these results can be relied upon implicitly, as the circumstances under which they are made, the size and condition of the horses, etc.,

would preclude the possibility of the compilation of accurate tables that might be applied to every case. But still they give results sufficiently accurate for the purpose here. Trautwine gives tabulated results of certain of these tests, from which we are led to the conclusion that, approximately, only one-third as great a load can be hauled up a gradient of 6 per cent as can be drawn on a level; only 40 per cent of the maximum load on a level can be drawn up a grade of 5 per cent, about one-half as much for a rise of 4 feet in 100, and three-fourths of the maximum level load for a 1-per-cent grade. There seems to be a very slight difference in the tractive force required for grades as high as 3 per cent, beyond which it increases so rapidly that it is manifestly unwise to allow a gradient of more than 6 per cent on first-class roads, except it be absolutely out of the question by reason of the cost to reduce the grade to that amount either by going around the hill or by grading. On less important roads the grade might in some cases be as steep as 10 per cent. Of course by percentage is meant so many feet rise per 100 feet horizontally.

In order to show the results of grading, assume the following cases: Given a first-class road, a hill 500 feet feet long from bottom to top, rising 50 feet in that distance; maximum grade allowed, 6 per cent. To reduce the hill to the 6-per-cent grade a fill of 10 feet at the bottom and a cut of 10 feet at the top are required. The character of the soil is clay. The width of the road is to be on the surface 16 feet clear. On each side 2 feet are allowed for ditches, making the total width of base 20 feet. The slope of the sides is to be 45 degrees, or, as engineers say, one to one. The amount of the excavation will equal the amount of the embankment approximately, so that the line of division between

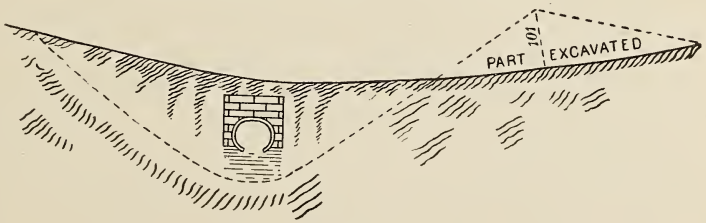

FIG. 1.

the excavation and the embankment is halfway up the hill. The number of cubic yards to be excavated is found by easy computation to be 1,234 approximately. The lead or average haul is 350 feet. In reliable earthwork tables, based upon the average wages of $1 per day for laborers, and $3.50 for each team and driver—an ample allowance—we get 10 cents as the cost per cubic yard for earthwork of the average haul given above, and employing wheeled scrapers for the work. This gives for the cost of the earthwork from the top to foot of hill $123.40. Now, by reducing the grade from the 10 per cent to one of 6 per cent, the new grade line will meet the level some 500 feet from the original place which marked the top of the hill, as shown in Fig. 1.

In other words, there is still a prismoidal mass of earth to be removed from the top of the hill to the embankment at the foot. On this part the average haul is less than 600 feet, and the cost of moving the earth over that distance is about 14 cents per cubic yard, using wheeled scrapers as before. Or, for the remaining 617 cubic yards the cost will be $92.75, or a total of only $216. And what is the result? Assume that throughout the entire year there is an average of only 50 vehicles a day ascending this hill whose average load is 1,000 pounds, i. e., 50,000 pounds a day, or something over 1,500,000 per year. A horse can pull 40 per cent more up a 6 per cent grade than he can up a 10 per cent grade; or, to put it a little differently, hauling 1,500,000 pounds up the 10 per cent requires the same exertion as hauling 2,100,000 pounds up the 6 per cent grade. The new and lighter grade during one year saves 600,000 pounds of surplus energy previously expended in climbing up the old steep gradient. Hauling 600,000 pounds 500 feet is the equivalent of 300,000,000 foot pounds; or, since a day's work for a horse is about 13,000,000 foot pounds, it means the work of about 25 horses for one day or one horse 25 days; amounting, at a fair valuation, to $25 or more. Had the grade remained at 10 per cent, $12.96 would have been saved in interest on the cost of grading and $25 lost in the extra work on the traffic. So that, reckoning from this standpoint alone, the assumption of the amount of traffic being correct, the improvement doubly repays the outlay.

But a still stronger light in which this case may be shown is the following example: Suppose that over this same road during the spring 100 loads of fertilizers are to be hauled by the farmers—by no means excessive for most of the Georgia roads leading out of even very small towns. Since the ratio for the 10 per cent grade is 25 per cent of the load on a level, a farmer could not reasonably expect to carry more than one-half a ton at a load with a two-horse team, while up the 6 per cent grade a load of 1,400 pounds, by the ratio deduced from the actual experiment, is carried with the same exertion. It would therefore require 200 trips over the 10 per cent and only 142 trips over the 6 per cent grade, a saving, therefore, of 58 trips. Suppose the distance is such that two trips a day can be made; allowing $3 per day for team and driver, the cost per trip is $1.50 or 58 trips, a saving of $63. Put this against $12.98, interest on cost of grading, and see how it looks just for the one item of fertilizers, which, of course, constitutes only a small percentage of the total annual tonnage.

COUNTER GRADES.

Counter grades should never be allowed. In all cases of ascent it is important that the rise be continuous, or, at least, that the grade line does not rise and fall alternately from bottom to top of the hill, since in that case the distance the grade is allowed to fall must be overcome a second time, doubling thereby the amount of work in overcoming that

much of the total rise. On long hills, however, it is allowable to have the grade lines alternate at intervals with levels for short distances in order to relieve the continuous strain. It is also important on long hills to have the steepest grade at the beginning of the ascent, in which case the grade diminishes as the muscular energy of the animal is expended.

GRADERS.

While on the subject of grades it may be well to note that there are a number of road machines which do highly efficient and satisfactory work, and do it, too, at a cost much less than it can possibly be done by other means; for example, the manufacturers of one machine, the "New Era," claim and guarantee that it will load wagons at the rate of 2 cents per cubic yard, and that their special dump wagons will deliver it in place at about 3 cents additional on hauls of 500 feet. So that, estimating from this basis, the cost of grading in the example above would be only half as great as the figures there given indicate—a saving which would certainly recommend itself to the constructors of roads, especially in level countries where soft earth is encountered, such, for example, as that found in the southern part of the State. The use of the machine, however, is by no means restricted to soils of that character. Its cost is about $1,200, but the great saving in the cost of earthwork by its use would undoubtedly repay many times over the interest on the outlay, taking as true the claims made for it by the manufacturers and of which they give a very strong guarantee.

FORM OF ROADWAY.

Of the exact shape which should be given to roadways there are a variety of opinions, but agreeing in one essential point, that is, that the road should be higher in the middle and slope off towards the side drains. Some engineers and road-builders advocate a curved surface approximating to a circle of large radius, the slope being in the neighborhood of one in twenty or thirty, or for a road 16 feet wide a rise of about 3 to 5 inches in the middle. In construction the road should be given a little greater rise than this to allow for its being contracted by a constant travel. The proper form of roadways, with the arrangement and shape of side drains, is shown in Figs. 2 and 3.

FIG. 2.

The surface is not circular, but is that of two planes joined by a slight curve, the slope being, as previously indicated, about 1 foot in 20 feet. But this slope is not to be considered invariable. It should not be less than that, but if the road should descend at a greater rate than five in one hundred, longitudinally, then the slope toward the side drains

should be so increased that the water will not make an angle of more than 45 degrees with the axis or center line of the road in going to side ditches; thus preventing its flowing down for some distance along the line of the roadbed, and resulting in consequent injury by washing the surface into gullies. Since the object is to get the water off the roadbed as soon as possible, it might seem that the better plan would be to give the sides a much greater slope; but the objection is that in that case vehicles passing along any part of the road surface, except the middle, would have so great an inclination from the vertical as to render it uncomfortable for passengers, and besides cause a tendency of the wheels to slide along the slope, resulting in some loss of power and also in injury to the roadbed, the tendency of such action being to grind or scrape the earth toward the side of the road.

SIDE-HILL WORK.

In constructing a road around the side of a hill, it will become necessary upon the same cross section, perhaps, to have the earth excavated

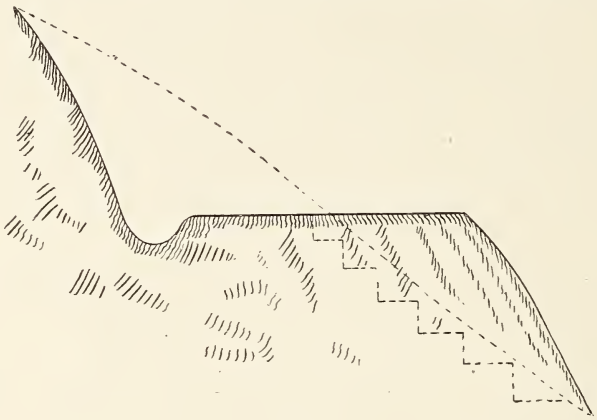

FIG. 3.

from the upper side and filled in upon the lower in order to bring the road surface to the proper level. This is known as side-hill work and is shown in Fig. 3 above. The sides of the cut and fill should slope at a certain degree depending upon the soil, being for clay usually about 45 degrees, or one to one in cuts. Loose earth requires a less degree of slant. For the embankment the earth is given a slope a little less than that which it would assume naturally. If the inclination is very steep then it may be necessary to cut "steps" in the side of the hill in order that the earth of the embankment may secure a firm hold; or it may become necessary in extreme cases to build a retaining wall at the foot. In all cases, of course, the road surface should be sloped not from the middle toward each side, but from the outside of the curve inward. This is upon the same principle which governs the elevation of the outer rail upon railroad curves, made necessary on account of the

centrifugal force generated at those points. Also in side-hill work, and in all cases where much water is liable to flow down the hill into the road or the side ditches, it is advantageous to cut a ditch some distance up on the side of the hill to take away this surface water, and prevent its reaching the side drains to augment the washing, and, moreover, to wash sediment into them, causing them soon to become clogged with trash and dirt, and rendered inefficient thereby.

DRAINAGE.

Of paramount importance is the subject of drainage. Without it no road can be a good one, and with thorough drainage even the poorest dirt road can be made reasonably good. Water is the most aggressive of all the destroying agents, and to render its work of as little effect as possible, thorough drainage must be provided, both for the purpose of taking away as much as possible of the water that falls upon the surface and as quickly as it may be done, that is, surface-drainage; and also to deprive the soil of that water which sinks into it by providing channels for its escape underneath the surface, or what is called subdrainage. The adoption of one or both of these methods will depend entirely upon the locality and character of the soil. But this much may be stated, that along the entire length of the road there must be some provision made for drainage. Even along level stretches it is very essential that at least shallow side ditches be constructed. Except under the most favorable conditions of soil, such, for example, as a sandy loam through which the water percolates rapidly, as occurs in most of the counties of southern Georgia, it is not expedient to have the roadway level longitudinally for any considerable distance, but rather to give it a gentle slope by alternately rising and falling at the rate of about 1 foot in every 400 or 500 feet, in order to let the water flow off. The side ditches should not be less than 6 inches in depth in any locality, and not less than 12 inches wide at the top. They should be circular or rounding in cross section at the bottom in order that the water by the contracting of the channel in this way may flow off more rapidly; the tendency being in the case of a flat bottom for the flow to be less rapid by reason of its spreading out, consequently causing sediment to be more readily deposited, and the ditch thus obstructed. With ditches having a cross section like the letter V, the tendency is for the water to cut them out too rapidly.

From the minimum dimensions given above the drains are increased according to the governing circumstances. For instance, if the soil is clay, particularly liable to hold water, they should be sunk to at least 2 feet in depth where the longitudinal slope is as much as 1 per cent. The deeper side drain not only serves to carry off the surface water, but it offers at all times an escape for some of the water to percolate out from beneath the roadbed. The determination of the size of the

ditches is the province of the skillful roadmaker, who will be governed by data obtained at the place and an accurate knowledge of all the conditions. Therefore no definite rule can be given in a paper of this nature. It is essential in all cases to provide a drain sufficiently large to carry off all the surface water of ordinary rains, and even of storms, without overflowing. To aid him in making this determination a knowledge of the rainfall is required, basing his estimate upon the amount of water that will fall upon the area of the roadbed to be drained during the heaviest downpours. He will have given, then, the number of cubic feet of water per minute to be removed, the area of roadway to be drained and the slope of road, to determine the size of ditch required. In this problem he will take into account not only the water falling into the road and the ditches themselves, but also the probable amount that will flow down from the side hills. The size of the ditch will be determined at various points. The greatest area will be at the foot of the hill and will diminish gradually to the minimum cross section at the summit. In the matter of ditching this much may be added, that there is frequently more efficiency in a scientific scratch than there would be in a ditch 3 or 4 feet deep.

CROSS DRAINS.

In the rushing down of great volumes of water it may be expected that the soil, unless it is of a very resistible kind, will gradually be carried off to the foot of the hill, leaving a widening and deepening gully, which may in time become dangerous to vehicles and passengers and destructive to the road as well. Consequently upon long hills which descend at a steep grade it is necessary to provide against this evil. This may be done by widening the ditches, giving them a flattened form. But in the case of a deep cut, where this arrangement would necessitate the excavation of a large amount of earth, cross drains are constructed at intervals where the configuration of the surface will permit, by means of which the water is diverted from the road before it acquires much volume and force in its descent. Should neither of these methods be found practicable, then the plan is adopted of excavating a trench and laying drain pipes of capacity sufficient for the service required of them. These pipes should be laid 2 or 3 feet below the surface on a firm bed, so that the earth will not become soft enough to allow the pipes to sink at one end and rise at the other, causing a break in the drain. For this pipe ordinary glazed or unglazed farm tiling (preferably the former) may be used. The round or oval form should be employed for the reason given previously in regard to ditches, viz, that it offers the best form of channel for conducting away the water without depositing its load of sediment. These pipes are laid end to end with the joints open, that is, not cemented, but fitting as close as the rough surface will permit. This arrangement will prove

satisfactory provided that the bed is perfectly firm, and may be relied upon to remain so; otherwise the conduit may become disjointed and the drain useless. To obviate this possibility, collars are made to fit around the joints which prevent their rising or sinking, and, of course, they will hardly be able to pull apart by slipping lengthwise. Collars will increase the cost slightly, but at most they should not be very expensive. The drains should have packed around them small broken stones or pebbles, and the trench filled with these and with coarse gravel to the top. This is shown in Fig. 4.

FIG. 4.

Usually where such drainage is needed a sufficient quantity of this filling material can be obtained in the vicinity. The object of this arrangement is to allow the water from the road to percolate rapidly through to the drain which it enters at the joints; for it must be remembered that these joints were not cemented, and although the openings between them are very minute, there are a great many joints which allow, in the aggregate, a large quantity of water to enter.

There might be some doubt as to the efficiency of this arrangement alone, however, in the case of rain storms, and so to provide further for the rapid escape of surface water, inlets covered with grating should be provided at suitable intervals along this drain. The objection might be made that the surface water entering the pipes directly would carry into them a vast amount of sediment and choke them up. Of this contingency there is little danger to be apprehended, because it is only on steep hills that the method would be resorted to, and in that case the amount of fall would cause the flood water to scour out any deposit of sediment that may have been left there by the more sluggish flow of light showers. This formation of drain will prove valuable, also, as a conduit for the water seeping out from underneath the roadway, thus at the same time serving the purposes of surface and of sub-drainage.

SUBDRAINAGE.

But the arrangement indicated above is not sufficient to keep the roadbed dry if it is a sticky, viscous, clay soil. Here it is necessary to provide a more thorough system of subdrainage. To do this, either cross drains should be placed at intervals or longitudinal drains laid along the direction of the axis, and communicating at intervals with the side drains into which they discharge their waters. The latter is perhaps the better method.

The arrangement and construction shown in Fg. 5 will be as follows: If a single drain is to be used, extending along the center of the road, the trench is excavated some 2 feet or more in depth, but not lower than the bottom of the side drains, because the latter are to receive the discharge of the former. The earth is excavated so as to form a

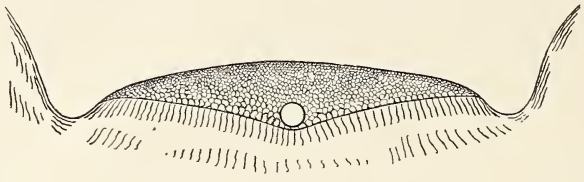

FIG. 5.

bed having a considerable slope from the sides to this trench. This bed is thoroughly compacted and smoothed off to allow the water to flow down it freely rather than sink into it. This of course refers to a stiff clay, as the arrangement would not be required in gravelly or loamy soil. The drain pipe, consisting of joints of ordinary farm drain tile, is laid along this trench on as firm and unyielding bed as the clay will furnish, and then the whole of the excavation filled with small stones and gravel. Coarse sand will answer in case the other material should not be available. Upon this is put a surfacing of the local material, such as clay mixed with sand or gravel, to a depth of about 6 inches, the whole being shaped off to the required form and thoroughly compacted. In some cases it may be necessary to arrange more than one of these longitudinal drains. The same arrangement is followed except that the bed strata will be shaped to convey the water to the two drains instead of to one.

CULVERTS.

Culverts are often necessary to carry the surface water across the roadway, as well as at the crossings of small streams, when obstructed by the grading. This work should be done in a thorough and intelligent manner, having due regard for permanence and efficiency. The size of the pipe or of the passageway will depend upon the volume of water to be discharged and should be equal to any emergency that will be likely to arise. To determine this, certain data must be obtained in regard to the flow, the area of the watershed, and the annual rainfall. In all cases it should be large enough to pass all the water through as fast as it arrives, otherwise it would accumulate and form a pond above the embankment, soaking into it and softening the roadway. These culverts are usually made of vitrified pipe thoroughly jointed and carefully laid in a bed prepared for its reception, which should always be sufficiently firm to prevent the sinking down of the pipe at any part by reason of the softening influence of the water, or the loads passing above it on the road. No fears need be entertained as to the strength of this kind of drain, as it will always be sufficiently strong to resist the pres-

sure brought to bear upon it if it is placed as deep as 2 feet or more beneath the surface. Sometimes two lengths of pipe of smaller diameter are laid side by side, rather than a single pipe of larger diameter. If the culvert is very large it is usually constructed of brick, or of rubble masonry if stone is to be obtained in the vicinity, laid with cement mortar and resting upon a good foundation. The bottom is slightly concave and with an approximately smooth surface. The ends of the pipe culverts should, as a rule, be protected by facings of brick, or other masonry, or of wood, though they are sometimes left free. The discharging end of the culvert should always be several inches lower than the upstream end to facilitate the flow and prevent the deposition of sediment.

BRIDGES.

One of the most essential features of good highways is that of bridge construction. At all crossings of streams which might at any time interrupt the passage of vehicles, good substantial iron bridges should be erected where the importance of the highway is sufficient to warrant the outlay; and in all cases where bridges are necessary, they should be of the most permanent character possible to make them by placing them upon masonry piers resting upon firm foundations, and protecting them by roofs and walls against the destroying agency of water. Good bridges, besides being more economical, appeal strongly to the eye of the traveler and cause a feeling of pride on the part of every citizen, which the Government for manifest economic reasons owes it to encourage, even though the saving of dollars and cents did not appeal so strongly to the same end. This result can be reached only by intrusting to a competent engineer the work of bridge building.

ROLLING.

Every part of the road surface after being brought to the desired shape should be thoroughly compacted by repeated rolling with a 5 or 6-ton road roller. This is an indispensable part of every road equipment. The cost of a 6-ton horse roller is about $500 or $600. The steam rollers are of course preferable, but their cost will generally preclude their use upon the common roads, at least for some time to come. Shorter rollers are better than longer ones of the same weight, as they afford a greater pressure upon any given area. The bottom and sides of ditches should also be thoroughly compacted.

IMPROVEMENT OF ROADS.

Hitherto in this paper the discussion has been confined to the questions relating to the laying out, shaping, and draining of roads. A few suggestions are now offered as to the manner of treatment of the existing roads on those points not already covered in the preceding pages.

SANDY ROADS.

That section of the State south of Macon is composed for the most part of a sandy loam, the character of soil which presents the conditions most favorable to the construction of good roads. It is of such a nature that it is easily drained, the water falling upon it usually sinking into and through it and giving little trouble to the road-maker. The greatest trouble encountered in this section of the State is in the deep beds of sand which accumulate and through which vehicles are drawn with great difficulty and at great expense of animal power. In dry weather they are much worse than steep hills having a hard surface. To free the road of these beds of sand would be one thing needful in providing for the improvement of the roads in that section or wherever they should occur. In most cases this would prove a very simple problem, it being necessary very often simply to remove the sand by means of scrapers to the depth of the underlying clay, depositing it outside of the road, or removing it to some part of the road if there should be such in the vicinity where it could be advantageously used. Having removed the sand, build up the road to the proper shape and provide the proper drainage to prevent the sand washing back upon the roadbed. If the sand should not be underlaid with a firm soil it will be necessary to cover the surface with clay or some hard covering to a depth of 6 inches or more; it should then be rolled and properly shaped, and the necessary ditches provided for drainage. In case the soil of a road is a sticky, stiff clay, then it may be greatly improved by carting sand or gravel upon it, which becomes mixed with the clay, rendering it drier, harder, and more porous.

ALIGNMENT OF EXISTING ROADS.

No work of the character contemplated under this improved system looking to permanency should under any circumstances be done upon existing roads until the same have been newly aligned with due reference to grades, distances, and drainage, straightening them where deemed necessary and *vice versa*. This might possibly lead to some trouble because of the opposition of citizens along the road whose direction it is proposed to change. They, of course, have certain rights, which the proper authorities would be bound to consider before ordering any change to be made. But even if small amounts for damages should be incurred occasionally, it is immeasurably better that the alignment should be most advantageously made looking to its permanence, rather than that by reason of a bad location a constant tax be levied upon every traveler upon the road for all future time. For, once located and improved it becomes to a degree permanent, and with every passing year it becomes the more so by reason of residences and improvements that will certainly follow a good highway. Radical changes of large sections of the present roads will seldom be needed, and minor changes can be effected without undue cost.

HARD-SURFACE ROADS.

These are of two principal kinds, known as telford and macadam roads. So far only dirt roads and questions relating to them have been discussed. The time has not yet come when Georgia can undertake upon an extensive scale the construction of stone-surfaced roads. The splendid road systems of France, of England, of Italy, of Germany, and of Austria are the outcome of long years of systematic improvement. To duplicate them in Georgia will likewise require many years, but to inaugurate a definite plan and make the most of our own resources as soon as possible, is the part of wise State policy. Fortunately there are few sections of the State where these expensive roads are absolutely necessary, since, by the skillful direction of the resources at hand, it is possible to render almost all the dirt roads passably good and a great number of them excellent; in fact, even preferable to the stone-surfaced roads by reason of the easy and noiseless traction upon them. There will, however, be certain parts of important roads where a stone surface will be absolutely essential. This will be in the vicinity of large towns and cities where there is a great deal of traffic, and where in the wet seasons mud is formed to such an extent as to render them practically impassable, and where no ordinary drainage arrangement will be adequate to remedy the evil. In such cases a beginning should be made looking to the gradual extension of the hard-road system. A small amount of this hard surfacing might be constructed each year upon the most needful portions of the roads, with the view to its gradual completion as the growing population and increasing demands of commerce should necessitate.

The macadam and the telford roads differ very little in the principle of their construction, consisting essentially of successive courses or layers of broken stone of varying dimensions, according to position; the largest, which for the macadamized roads are about $2\frac{1}{2}$ inches in size, approximately cubical in form, being placed in the bottom layer on a bed of earth prepared to receive them. This layer is then rolled with a heavy roller and brought to a comparatively smooth surface. Upon this a second layer of smaller stones is placed and rolled in a similar manner. A third layer of broken stones, about $1\frac{1}{2}$ inches in their greatest dimension, finishes the metaling. The covering is then given the proper shape and the whole compacted to a smooth surface by passing the roller over it repeatedly. This causes the stones to become firmly bound together, forming a hard smooth roadway. The whole of the finished roadbed will have a thickness ranging from a minimum of about 6 inches to a maximum of about 15 inches in the center, being a little thinner at the sides than in the center. The thinner surfaced roads have come much into favor during the past few years, as a number of them, notably in Bridgeport, Conn., have proven highly efficient and satisfactory in every particular, more especially in the very impor-

tant item of cost, which always varies about in the same ratio as the thickness.

The telford roads differ from the macadam in having a foundation course of stone blocks about 6 or 7 inches deep and 3 or 4 inches in the other dimensions laid out on a level foundation. The thickness of the stone diminishes at the sides to give the road the proper slope. On this foundation is placed the courses of smaller stones until the thickness is about 12 inches in the center. The main advantage claimed for the telford roads is that this foundation course prevents the small stones from working into the earth of the bed. The best kinds of stone from which to make the metaling of both telford and macadam roads are granite, gneiss, hard silicious sandstone, and traprock. An ample supply of granite and gneiss is available throughout the hilly sections of the State, where hard-surfaced roads will be most largely required. The cost of these roads, either the macadam or the telford, will range, for a 16-foot road, from $3,000 to $10,000 per mile according to thickness. The cost need not much exceed the former figure in this State, the abundance and accessibility of material considered, as the thinner roads have proved adequate to the demands made upon them in every case where they have been tried.

ROAD MAINTENANCE.

Under this head there remains little to be said regarding the work to be done, as that has already been indicated in the foregoing discussion. Hence, under this caption will be discussed, as being germane to the subject of maintenance, the questions of the organization of the road force, the necessary equipment of the same, and the convict problem, with estimates of cost and the consequent effect upon the tax rate.

DISTRICT ENGINEERS.

As to the organization of the road force, there is suggested, first, the employment of thoroughly competent civil engineers to have charge of the roads and bridges of the senatorial districts. The salary of this office should be such as to command the services of first-class professional men of recognized ability and fitness for the important work intrusted to them. One engineer would be competent to direct the work of several counties, and therefore a senatorial district is suggested as the territory to be placed under his supervision. He will require the assistance of two chainmen, a rodman, and an axman in the work of the surveys, for the employment of whom provision should be made either in the adjustment of his salary or by allowing a sufficient sum for expenses. These assistants would not be permanently retained on salary, but only employed as required, nor need they be other than ordinarily intelligent laborers.

The power of appointing engineers should be given to the governor of the State, who would make the nominations, subject to the confirmation of the legislature or of the senate (preferably the latter body alone), the term of office to continue not less than four years, for obvious reasons, unless for a good cause a removal should be deemed advisable. The engineer should be *ex officio* a member of the board of commissioners of roads and revenues of the counties in his district where such bodies exist, and it should be his duty to advise with and to act by the authority of said boards or the officer having jurisdiction over such matters. He should be equipped with the instruments and conveyances requisite in the discharge of his duties. It is not necessary to enumerate in detail the duties devolving upon such an officer; but forming no unimportant part of his work would be the engineering of all bridges in the district—an item upon which too great stress can not be laid in advocating the appointment of such an officer. All work should be done only after the proper surveys have been made by the engineer, and careful, accurate, and explicit specifications and drawings prepared for the guidance of the foreman or contractor, and it would, of course, devolve upon him to have them faithfully carried out in every particular.

STATE ENGINEER.

As a means of uniting the separate systems into one working in common to the accomplishment of the highest degree of proficiency possible, the appointment of a State engineer is advisable. His office should be in the capital, and his duties should be those of a consulting engineer, to furnish his opinions and advice upon matters referred to him by the district engineers. He should, moreover, be required to visit and personally inspect the road and bridge work of every district in the State at least once a year; to make annual reports to the general assembly upon the work being done; to report for investigation all cases of irregularity or incompetency upon the part of the district engineers, and to make such suggestions as he might deem advisable looking to the improvement of the system. He should command a salary in keeping with the importance and requirements of the office.

ROAD EQUIPMENT.

The proper equipment of a road force for one county would consist of a 6-ton horse road-roller, 1 road machine, to be employed in grading, ditching, and shaping the roads, 2 road plows, 2 drag scrapers, 2 wheeled scrapers, 2 dump carts, 1 4-horse wagon, 1 2-horse wagon, 2 complete camping outfits, large and small, 6 draft horses or mules, and the requisite number of hoes, axes, shovels, and other small implements necessary in the work. The whole equipment would cost less than $2,500 for each county, including its pro rata part of the engineer's outfit.

ROAD MACHINES.

It is important that a road machine be included in the equipment of every county, as it will undoubtedly repay the cost many times in a very short while. Their makers guarantee them capable of doing almost all kinds of work necessary to be done on earth roads and at a saving of 75 per cent in the cost of the same by other methods. By its use a vast deal more work could be done, and soon the roads would be put in good shape and condition, after which the cost of maintenance would be reduced to a minimum. The use of these machines is no longer an experiment, but their efficiency has been clearly demonstrated in this State, as a number of them are now successfully operated in the counties of Richmond, Floyd, Chatham, Muscogee, and Bibb.

FOREMAN.

There should be for each county a foreman of the road force, who should be a man of some education and a good fund of common sense, together with the firmness and ability necessary to direct the execution of the work. Such a person could be employed at a salary of about $600.

LABOR.

The next question which presents itself is that of laborers and of whom they should consist. In order to arrive at a satisfactory solution of the problem it will be necessary to discuss it from three distinct standpoints, viz, the present system, the system of paid labor, and that of convict labor, and by carefully computing the cost of each arrive at an intelligent conclusion as to which one offers the greatest advantages.

PRESENT SYSTEM.

In estimating the probable number that should constitute the road force it is necessary to assume a case based as nearly as possible upon actual existing conditions. Suppose there are in a district 3,000 men who are subject, under the present system, to road duty. They are occupied during the year about five days on the pretense of working the roads. The value of their labor is, at a low estimate, at least $10,000. The cost, then, of maintaining the roads per year has been $10,000, and no lasting good effected.

PAID LABOR.

The equivalent of 3,000 men for five days is 50 men for 300 days, or the entire year, allowing for holidays. In other words, 50 men working no more than this "conscript" force will be able to do the same work as is now done in that district, and do it in a preëminently more satis-

factory manner. That a paid force of good, able-bodied men who receive $1 per day as wages will do twice as much work as the "personal service" force is putting it at a very low estimate, the justness of which no one would attempt to question; that is, if laborers are employed at $1 per day each, the cost per year for 50 hands is $15,000, but at least twice the amount of work is done as at present; or for $7,500 the same amount of work is done as by the present method, which has been shown to be worth at least $10,000. True, in order to have the work done requires the supervision of a foreman, whose salary must be added to this estimate, so that in round numbers we may place the cost at $8,000. This result was arrived at, too, upon a valuation of only 66⅔ cents per day for one class of labor and $1 for the others. Putting both upon the same basis the result is nearly 50 per cent advantage in favor of paid labor. But this estimate was reached upon the assumption that the paid hand does twice as much as the ordinary road laborer. If this conclusion is correct, then only 25 good laborers would be required to do the work now done by the whole road population. If an estimate of the advantage of one system over the other is to be made it must be upon a basis of the same amount of work. Has this been done? No fair-minded man, cognizant of the workings of the present system, can deny that it has.

The road hand arrives at the appointed meeting place, where the road work is to begin, at any time from 8 to 10 o'clock in the morning. He is equipped with an apology for a weeding hoe, perhaps, which he uses vigorously for a few minutes pulling loose earth out of the ditches and placing it upon the road, to be speedily carried back by the next rain. He then rests two or three times as long as he has worked, discussing public and other questions; takes two hours at noon, and goes home early in the afternoon, having done about three or four hours' work during the whole day. Unfortunately, there are no statistics upon this point; but the argument in favor of paid labor does not stand upon this alone, as will be demonstrated further on in this discussion.

The road work then of this assumed district may be safely intrusted to 25 good, able-bodied laborers; however, "to make assurance doubly sure," let the calculation be made upon a basis of 30. This statement of the annual road expense will then stand about as follows:

Thirty laborers, three hundred days, at $1	$9,000
Three foremen of road forces, $600	1,800
Engineer's salary and assistance	2,000
Cost of keeping 18 horses one year	1,500
Interest on cost of equipment, $7,500 at 8 per cent	600
Incidentals	100
Total	15,000

To this account must be credited not only the work of the laborers, but also that of 18 head of mules or horses, the cost of purchase of which is included in the expense of equipment. The work of a horse is equivalent to the work of from 2 to 10 men, and, as horses can be

advantageously employed in almost all the road work, there is a big item to be placed to the credit of paid labor. Estimating from the least value given above the work of 18 horses is equivalent to that of 36 men, which, added to 30, the number of laborers employed, gives the work of 66 men; that is, more than twice as much work can be done employing only 30 hands as by the present system is done by 3,000 men called out five days during the year. Since twice as much work is done the cost of the same amount as done by the present labor will be only one-half of $15,000, or $7,500—a saving of 25 per cent. This percentage might still further be increased by assuming a greater relative value for the work of a horse; so that there can be no question of the justness of the claim that 25 to 100 per cent over the old system is saved by the employment of free paid labor.

CONVICT LABOR.

Unquestionably there is no more vital question before the people of Georgia to-day than the road question, and the convict problem as bearing upon it. The solution of the one in the opinion of a large number of the thinking men of our whole country implies a settlement of the other, because, through the employment of the convicts upon the public roads is offered a rational solution of the road question; and the maintenance of the roads by means of convict labor is the only possible satisfactory adjustment of the weighty problem of the proper disposition to be made of the convicts. Recently a great tidal wave of public opinion in favor of working the convicts upon the public roads has swept over the country, so that if the question were submitted to the suffrage of the people it would undoubtedly receive their overwhelming indorsement. The employment of the convicts upon the roads is the only means to prevent their competition with free labor. This competition has often in recent years been the cause of serious trouble, and even of deadly conflict. Its perpetuation is a constant menace to the peace of the people, and often a source of great expense to the State, necessitating the resort to military force to maintain order. That this unequal competition results in hardships to the people of many States is beyond question; and since it is unnecessary as well as unjust it should be abolished as soon as possible. This can be done easily and satisfactorily, and without depriving the schools of the State of one cent of the income, insignificant as it is, that they now enjoy from the lease of the convicts.

There are now in this State, in round numbers, 1,900 male penitentiary convicts, the lease of whom yields to the State a yearly income of $25,000. There are probably at least 600 more chain-gang convicts, yielding a small income to the individual counties. It would not, then, be an exaggerated statement to say that there are 2,400 convicts, all told, that would be available for road work. This will be an ample force for the requirements, since it would give about 50 for each 3,000 of road population.

In a previous estimate for free-paid labor it has been shown that 30 men working the entire year would do as much work as by the present method the whole population of the assumed district; so that, if 50 convicts are allotted to this district nearly twice as much work can be done as is indicated by those figures, which effectually proves the sufficiency of the convicts to do the road work of the State.

COST OF CONVICT LABOR.

In the able and exhaustive paper upon the subject of convict labor read before the Georgia road congress in 1889, by the Hon. W. A. Huff, the cost of maintenance of convicts, allowing for all contingencies, is given at 33¼ cents per convict per day. This is a safe figure to base the estimate of cost upon, as ample allowance has been made in every item going to make up the sum total of expenses. Hon. W. F. Eve, of Richmond, gave the cost at 31 cents per day, that being the actual cost of maintaining the convicts upon the roads in that county. As the relative cost of the three systems is to be shown, the estimates must be made upon the same amount of labor. Expenses for one year will be then—

Payment to State for 30 convicts at $25 per annum	$750
Engineering expenses	2,000
Three foremen	1,800
Interest on road equipment at 8 per cent	600
Expense of 18 horses	1,500
Maintenance and guarding 30 convicts at 33¼ cents per day	3,640
Interest on cost of buildings, stockades, guns, etc	100
Incidentals	110
Total	10,500

Reducing this sum one-half to allow for the work of 18 horses, as in former estimates, the cost is $5,250, a saving of 40 per cent at least over the present system.

DISTRIBUTION OF CONVICTS.

The question of the equitable distribution of convicts in the event of the employment of this kind of labor, properly comes up here. The disposal of the chain-gang convicts is an easy matter, as they clearly belong to the counties in which they have been convicted. Let an estimate be made by the principal keeper of the number of State convicts to be apportioned in a given year. Of course the number being discharged will be compensated for by the new ones coming in. Then distribute these among the counties of the State according to the road population. By this is meant the population subject to road duty as at present. This would seem the most fair and equitable distribution, as it would put all the common roads in whatever part of the State more nearly on an equal footing. From the very nature of the case it would be manifestly wrong to make this apportionment according to the amount of property, even though the towns and cities be excluded in the estimate of wealth. The crimes for which this penal servitude is being exacted

are infractions of the laws of the State. The State represents the people, and the term "people" includes every citizen within the State, regardless of any property qualification whatever. This being true, every man is entitled to receive the same recompense resulting from the servitude exacted from the criminal as a penalty for this infraction of the law, whether his property be worth $100 or $1,000. The plan proposed would most nearly bring about this result. Having determined the number of State convicts to which each county should be entitled, the principal keeper would maintain that number constant, as nearly as possible, by directing the distribution of recruits in accordance with the discharges constantly taking place by reason of pardon, death, and expiration of term of sentence.

A strict account should be kept of the exact amount of service in each county and the same charged against the county by the State at such valuation as might be previously determined upon, so that the aggregate income to the State will be a certain stipulated sum to go to the school fund as now. In other words, the plan is simply to lease the convicts to the counties to be worked upon the public highways instead of leasing them to private individuals and corporations. The question might be asked, since the plan proposes to appropriate the income from the lease of the convicts to the school fund and the counties must be taxed to raise the sum for the payment of the lease, why not tax the counties directly for this sum to go to the school fund and receive the convict labor free? It is answered that, inasmuch as it is manifestly impossible to maintain a certain definite number of convicts in any county at all times, this plan makes it possible for each county to pay for only so much labor as it actually receives from the State. Again, it might be the case that some counties would not desire to employ the whole number allotted by the State, or even to employ convicts at all, and that other counties would wish to increase their force. This plan would meet that condition exactly. But it should of course be required that every county should take its full number in case there should not be this demand elsewhere. Such a contingency is by no means probable, the more reasonable supposition being that the demand would exceed the supply.

SUPPLEMENTARY LABOR.

In case there should not be a sufficient number of convicts in the State to construct and maintain its roads, provision should be made for supplementing the force with free paid labor. This need not, in anywise, bring about the contingency which many would suppose as the result of the employment of both kinds of labor, viz, the working together of the two. To avoid this, the following plan is proposed, which dovetails nicely into the whole scheme, and serves to make its operation perfect and complete. Obviously, if the road force is to do much work of a permanent character, such as that indicated in the preceding pages, it could not cover the whole county at intervals of

sufficient frequency to keep up the needed little repairs that require constant attention. To do this a small force not exceeding a half dozen men (usually three or four would be sufficient) should be equipped with the necessary camp outfit and small implements, hoes, axes, and the like, and equipment for transportation. The party should be in charge of a boss who could be relied upon to push the work; but as their work would consist only in making temporary repairs, removing trees that may have fallen across the road, etc., no especially able foreman would be required as in the case of the main road force. If there were a sufficient number of convicts for both forces, then the most reliable of them should be placed on this "patrol" force, in which case the foreman would be a sufficient guard.

FEMALE CONVICTS.

These convicts could easily be arranged for by the provision on the part of the counties for their employment in the making of convict clothing, laundrying, or other similar work. But as there are so few of this class of prisoners and special provision would be required for their accommodation separate from the others, it might be found more satisfactory to have them retained by the State for this purpose, the products of their handiwork being furnished to the county authorities as required at a stipulated price, covering the cost of production, including the price of their lease. The latter plan is much the more feasible.

ROAD FUNDS.

In order to improve the roads money is required. There is no way of avoiding that issue. The present system, while it exacts no direct payment of money, has been shown to be the most expensive of the three that have been discussed; but there is no tax which, when the results are fully appreciated, will be more cheerfully paid by the people than that required to maintain a system which frees them from the octopus-like grasp of a plan that still remains as a relic of feudalism and the dark ages. The present system of personal service is so manifestly wrong that it needs no discussion. In the language of an eminent authority on the subject of roads, "The road-tax system of personal service is unsound in principle, unjust in its operations, wasteful in its practice, and unsatisfactory in its results." It is in fact a travesty and a failure, having been tried everywhere and always found to be unsuccessful. If the system is to be changed, how then is the money to be raised? It is obviously fair and just that every citizen should pay a stipulated amount directly, as a road tax, in virtue of his release from all road duty. It is also manifestly just and wise that an ad valorem property tax should be levied in addition to this, since property owners receive the greater benefit from good roads.

Of the 3,000 men subject to road duty in the assumed district, including all men between the ages of 16 and 50, except the privileged few (or, more correctly, a privileged good many) who are relieved of the duties by reason of the nature of their occupation, a proper deduction should be made for those who are less than 21 years of age. Boys have none of the rights and privileges of citizenship, and it is not right to tax them. As a compensation for this, add to the number all other male citizens not physically unable to work or financially unable to pay the tax; levy a direct road tax of, say $3. This will raise $9,000. Assuming that the taxable property of this district amounts to $3,000,000, which is a fair average for 3,000 polls, then a tax rate of only one-fifth of 1 per cent would raise the sum of $6,000; total, $15,000, which, employing paid labor, is sufficient to have, as has been clearly demonstrated, twice as much work done as now. That is, to do the present work a direct tax of $1.50 and an ad valorem of one-tenth of 1 per cent is sufficient. Who would object to the payment of this small sum as a relief from road duty? By employing convict labor the above rate would be materially decreased.

TAXATION OF CITIES AND TOWNS.

That a part of the burden of road taxes should be borne by the cities and towns, there can be no question. And why should they not? They are unquestionably as greatly interested in the improvement of the roads as are the people of the country districts. Their interests are to a great extent mutual and inseparable, the one dependent upon the other—a fact that is patent to all thinking men and needs no argument at this juncture to prove, since the adjustment of the burden of taxation between the two in the most fair and equitable manner would more properly come as the result of the combined wisdom of our legislators, should the question ever come before them in this or some similar form, as unquestionably it will at no very distant day. It is suggested for the benefit of those who might, without consideration, be inclined to oppose such a measure, that of course a portion of this fund would revert back to the towns directly, as, for example, the county would be obliged to agree to maintain the streets of the town in as good condition as the country roads; or, in other words, to divide the money in proportion to the number of miles of streets as compared to the mileage of the country roads, or to provide for some such equitable distribution.

ECONOMY.

The results, then of these investigations have been as follows:

Cost of present system	$10,000
Cost of paid labor system	7,500
Cost of convict system	5,250

Considerations of economy would dictate the kind of labor to be employed without further comment. But there is, beyond and above

the saving in the cost of maintenance in either of the two last-named systems, an economy resulting from the better roads obtained which it is difficult to estimate accurately or to fully appreciate. Reference is made to the increased capacity of stock, at least one-fifth, 5 horses easily doing the work of 6; not only that, but the decreased wear and tear of vehicles is an item of economic interest, amounting, as it will, to many hundreds of dollars every year. There is, perhaps, an equal saving in the fact that hauling and marketing over good roads can be done in bad weather when stock would otherwise be standing idle in the stalls; thus all the good weather is left free for farm work. In a county with 3,000 head of horses, at present it is safe to say that 30 days out of each winter finds them in the stalls doing nothing. The food alone during that time involves a money value of $9,000 at the absurdly low estimate of $3 per head; nor will it be wise to forget the increased values of lands which invariably come with good roads. Better roads are economical in bringing the farmer in closer contact with the markets, affording him increased facilities for the transportation of his supplies. They conduce in a wonderful degree to the personal pride of the citizen and increase immeasurably the bodily comfort and celerity of the traveling public. They are potent factors in the advancement of education and the Christian religion, and increased happiness and prosperity follow with no sluggish footstep along the line of the smooth and ample highway.

CONCLUSION.

It has been shown by this discussion that the present system of road-working is a failure and a disgrace to civilization; that commerce demands a change; that better roads are the great and growing needs of the State. The principles underlying the construction of a good roads have been indicated and fully discussed in detail. The different kinds of roads likely to be required have been clearly presented, and the necessity has been shown of beginning the reform at once. The cost of the present system and its unsatisfactory results; the cost of doing the work by paid labor and its superiority to the present system; and the cost of convict labor and its economy over both paid labor and the present system, have been clearly shown and the justice and feasibility of the employment of the convicts upon the roads have been demonstrated—at least to the satisfaction of the author.

Much more might have been said on a question so broad and many-sided, but, with due regard to the fitness of things, this paper is submitted in its present form in the hope that it may lend some aid to the progress of a movement that involves so much for the future material, social, and educational well-being of this commonwealth.

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